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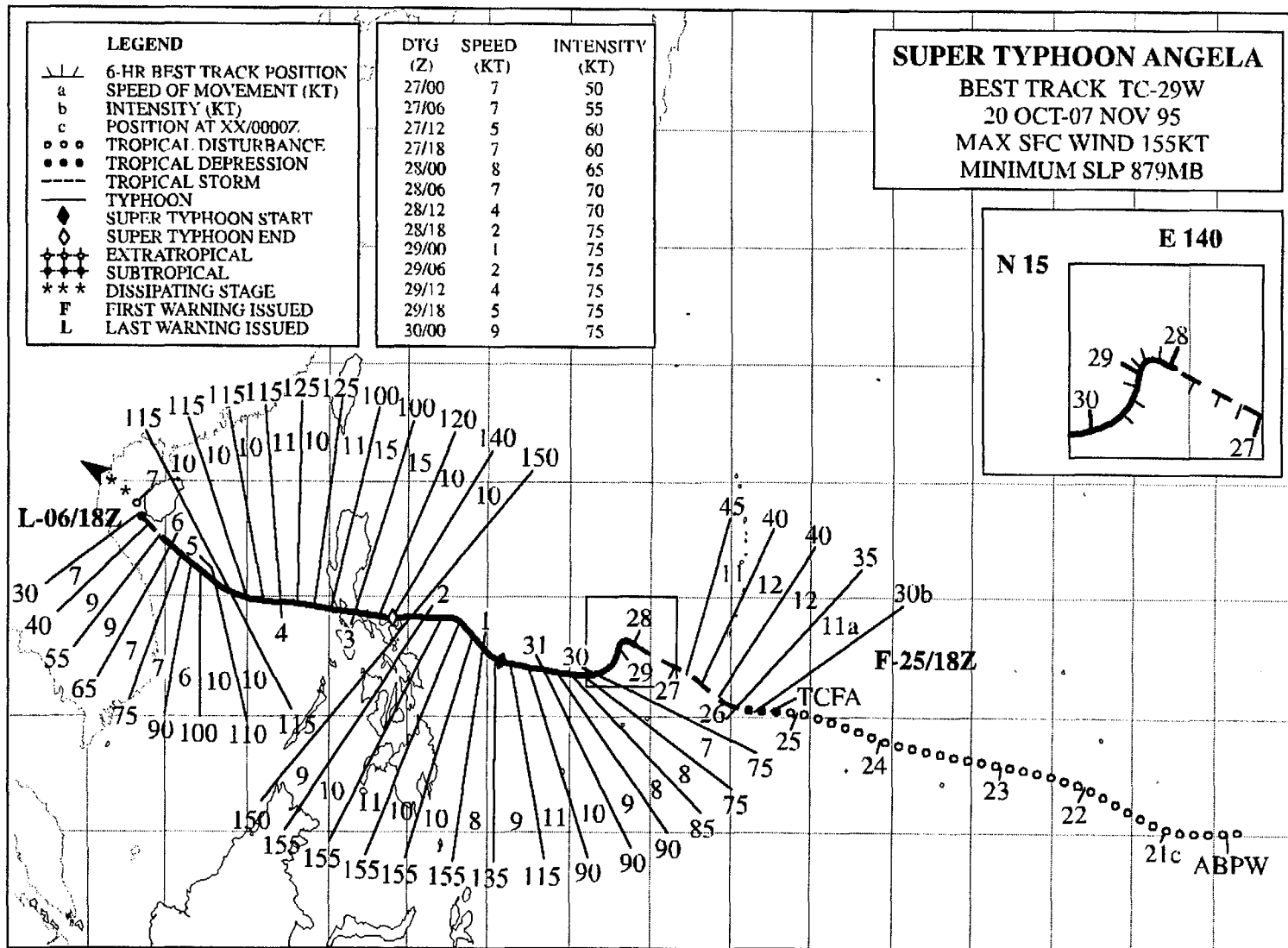
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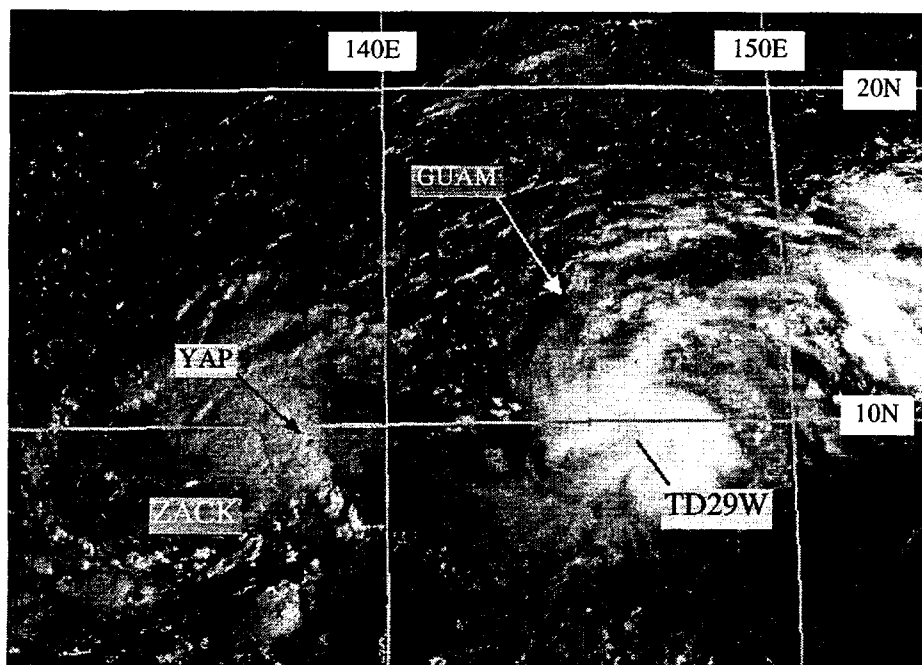
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## SUPER TYPHOON ANGELA (29W)



**Figure 3-29-1** Tropical Depression 29W at an intensity of 30 kt (15 m/sec). Tropical Storm Zack (28W) is located about 480 nm (890 km) to its west (252131Z October visible GMS imagery).

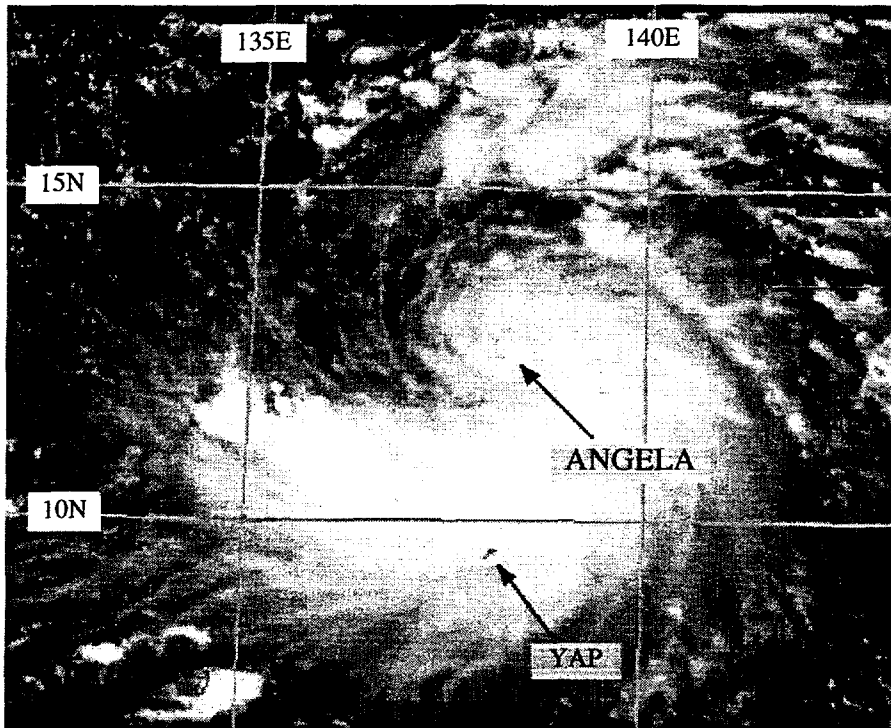
### I. HIGHLIGHTS

Angela was the most intense typhoon to hit the Philippines since Typhoon Joan (1970). First striking southern Luzon, it moved westward and crossed the metro-Manila area. More than 600 people perished in the Philippines as a result of Angela. Angela moved westward in tandem with Typhoon Zack (28W) nearly 4000 nm (7400 km) across the western North Pacific. Like many of the 1995 tropical cyclones, Angela was slow to develop, but ultimately, it became one of the most intense typhoons of the decade, peaking at an intensity of 155 kt (80 m/sec).

### II. TRACK AND INTENSITY

In the third week of October, as Ward (26W) was recurving and heading towards its eventual transition into an extratropical cyclone southeast of Japan, the monsoon trough again became active along 10°N, from 130°E to east of the international date line. This trough spawned three tropical cyclones that at one time existed simultaneously: Yvette (27W) in the South China Sea, Angela to the south of Guam, and Zack (28W) in between the two and located northwest of Palau. The earliest stages of Angela can be traced to a tropical disturbance that formed in the Marshall Islands. This disturbance was first mentioned on the 200600Z October Significant Tropical Weather Advisory. It moved toward the west-northwest for more than five days — in tandem with the tropical disturbance that became Zack (28W) — before finally organizing into a tropical depression. A Tropical Cyclone Formation Alert was issued at 251230Z when the disturbance was located 240 nm (450 km) south-southeast of Guam. The system continued to organize during the night hours of 25 October, and the first warning on Tropical Depression 29W (TD 29W) was issued by the JTWC, valid at 251800Z (Figure 3-29-1). Twelve hours later, as the system passed about 145 nm (270 km) to the south of Guam and took a more northwestward course, it was upgraded to a tropical storm. During the next two days, Angela slowly intensified as its

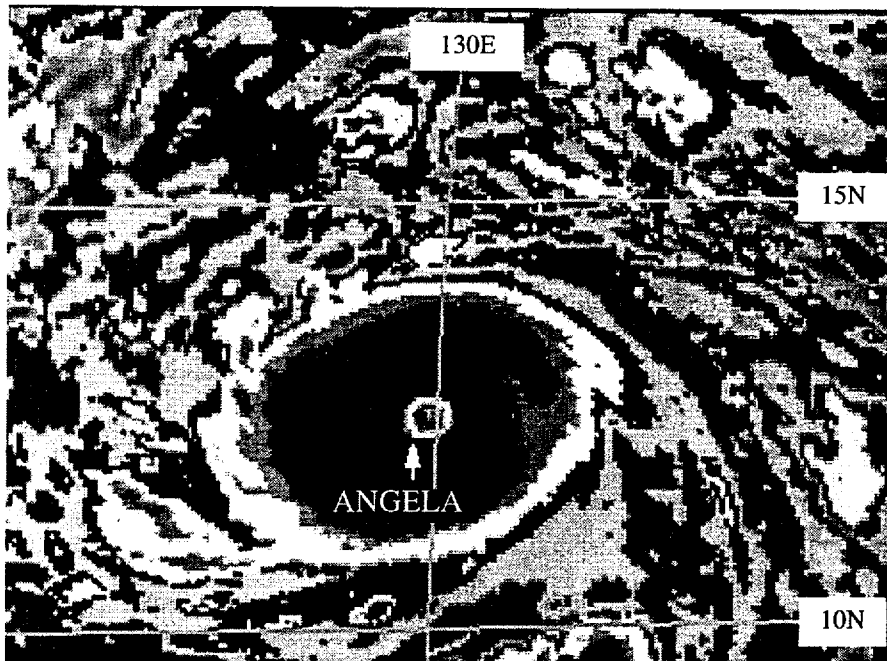
forward motion slowed to an average speed of 7 kt (13 km/hr). On the warning valid at 280000Z, Angela was upgraded to a typhoon. At 281200Z, the typhoon abruptly turned to the south-southwest (an unusual heading for a tropical cyclone). This erratic motion was at first difficult to detect due to the lack of a visible eye and frequently changing size, shape, and cloud-top temperatures of its central deep convection. During the 24-hour period of slow south-southwestward motion Angela maintained a 75 kt (39 m/sec) intensity (Figure 3-29-2).



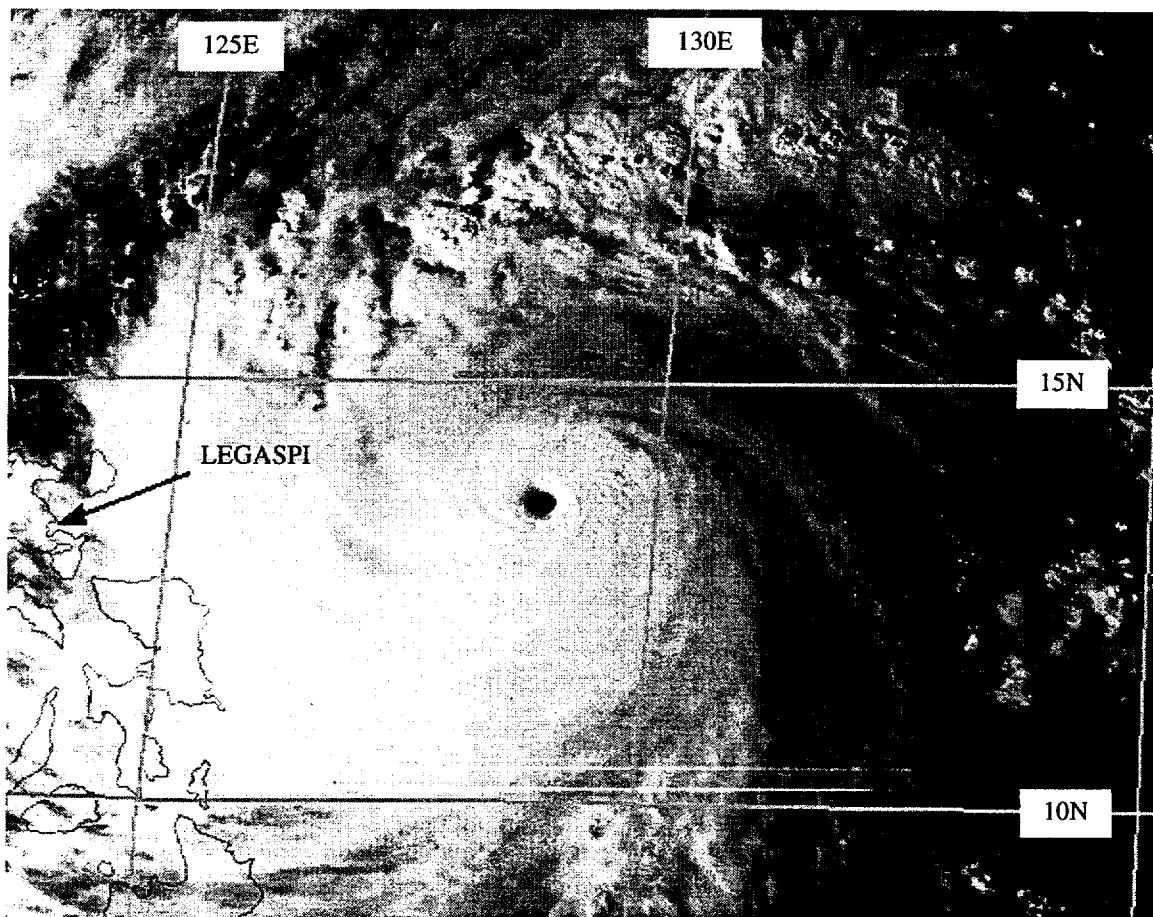
**Figure 3-29-2** Typhoon Angela moves slowly south-southwestward as it passes north of Yap (290631Z October visible GMS imagery).

On the morning of 30 October, Angela turned back to the west and accelerated to an average speed of 9 kt (17 km/hr). During the afternoon, the typhoon began to slowly intensify. At 310600Z, with an intensity of 90 kt (46 m/sec), Angela began to rapidly intensify (Figure 3-29-3), and 18 hours later, it reached its maximum intensity of 155 kt (80 m/sec) (Figure 3-29-4). (A more in-depth description of Angela's rapid intensification process, including digital Dvorak (DD) intensity estimates, is found in the Discussion Section).

On the morning of 01 November, Angela moved to the northwest for 18 hours, before heading west along 14°N latitude. Angela maintained its peak intensity for 36 hours before striking the northern Bicol region of southern Luzon. During 31 October through 01 November, Angela passed to the north of a Navy drifting buoy (WMO 52523). The data recorded by this buoy (Figure 3-29-5) were important for defining the radius of 35 kt (18 m/sec) and 50 kt (26 m/sec) winds (see the discussion section). Also, landfall data obtained from PAGASA for postanalysis provided valuable information concerning Angela's peak winds as it approached and crossed Luzon.



**Figure 3-29-3** Angela undergoing explosive deepening. At the time of this picture, its intensity was 140 kt (72 m/sec). The typhoon is located about 420 nm (780 km) northwest of Palau and 50 nm (95 km) east of one of the Navy drifting buoys (312231Z October enhanced infrared GMS imagery).



**Figure 3-29-4** Angela at peak intensity of 155 kt (80 m/sec) (010731Z November visible GMS imagery).

At 030600Z November, Angela exited the Philippines into the South China Sea with 100 kt (51 m/sec) sustained winds. It re-intensified to a peak of 125 kt (64 m/sec) in the South China Sea, then slowly weakened as it turned to the northwest toward Hanoi (Figure 3-29-6). On the evening of 05 November, Angela weakened further as a result of strong vertical shear imposed on it by the northeast monsoon in the low levels and strong westerlies in the middle and upper levels. The following afternoon, the typhoon was downgraded to a tropical storm. The final warning, valid at 061800Z, was issued as the system dissipated over the Gulf of Tonkin.

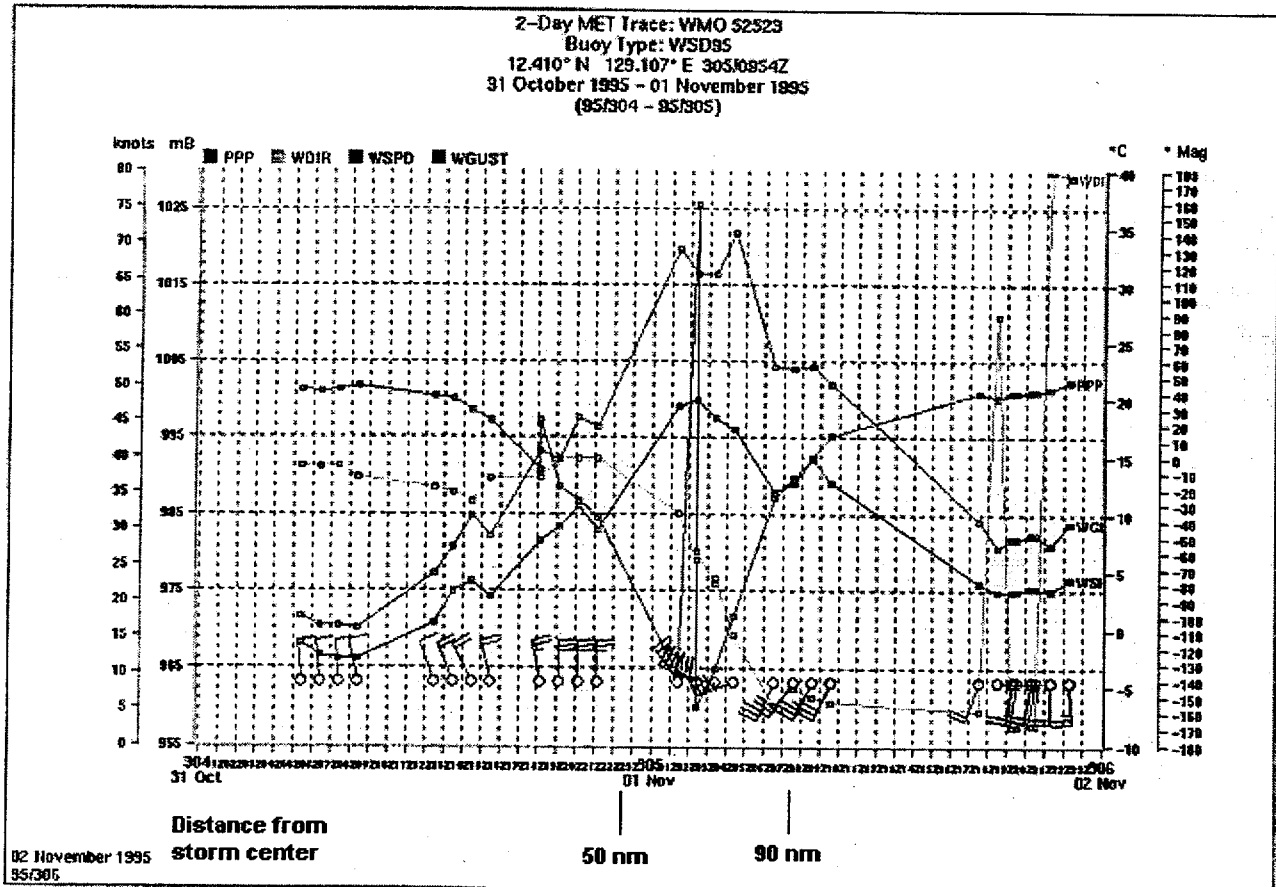
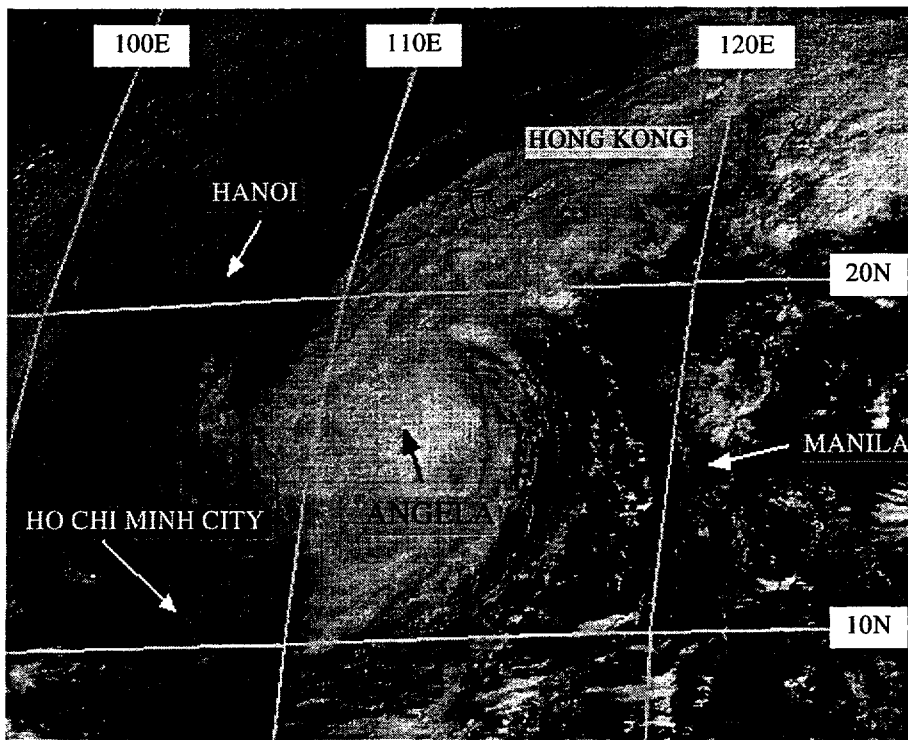


Figure 3-29-5 Two-day (31 October through 01 November) meteorogram from one of the Navy's drifting buoys, designated WMO 52523, as Angela passed by it. Sea-level pressure, 8-minute average wind speed, wind gusts, and wind direction are indicated.

### III. DISCUSSION

#### a. Erratic movement over the Philippine Sea

On 28 October, Angela's west-northwestward movement abruptly stopped, and the system moved slowly to the south — about 90 nm (170 km) over 24 hours. By 300000Z, the typhoon had resumed a westward track at 8-10 kt (15-19 km/hr). The sudden change in motion was not predicted. It is hypothesized that Angela was forced to move southward by the building of a subsidence-induced anticyclone between it and Zack (28W). As Zack and Angela moved in tandem to the west, the clouds between the two tropical cyclones rapidly dissipated on 28 October, indicative of subsidence, when the separation distance between the two tropical cyclones was only 540 nm (1000 km). This clearing was very evident on 29 October as Angela was moving slowly southward.



**Figure 3-29-6** Angela in the South China Sea (050031Z November visible GMS imagery).

#### b. Rapid intensification over the Philippine Sea

On 31 October, after Angela's intensity had reached 90 kt (46 m/sec), it began to rapidly intensify (Holliday and Thompson 1979). Eighteen hours later, Angela's maximum sustained wind had increased to 155 kt (80 m/sec). The equivalent pressure fall over this eighteen-hour period was 71 mb, and the average rate of fall was 3.94 mb/hr. This meets the criterion for a special case of rapid intensification called explosive deepening (Dunnavan 1981), in which the pressure decrease must exceed 2.5 mb/hr for at least 12 hours. Of interest, satellite imagery does not reveal significant differences between Angela's environment and that of other tropical cyclones that intensify at much slower rates.

At approximately 010200Z November, the center of Angela passed 40 nm (75 km) to the northeast of the Navy's drifting buoy (WMO 52523). Data from this buoy (Figure 3-29-5) helped to define the distribution of 35 kt (18 m/sec) and 50 kt (26 m/sec) winds on the south side of Angela. They depict a small radius of 35 kt (18 m/sec) wind in the southwestern quadrant during the explosive deepening phase of Angela. A peak gust of 72 kt (37 m/sec) and a minimum sea-level pressure of 960 mb was

recorded by the buoy.

c. *Measured winds and pressures as Angela crossed the Philippines*

As Angela approached the Philippines with 155 kt (80 m/sec) maximum sustained 1-minute winds, satellite intensity estimates began to indicate a weakening. Table 3-29-1 shows the T numbers, the current intensity (CI) numbers, DD numbers, and the intensity-based analysis of synoptic observations over the Philippines during the period 020000Z to 030300Z November (see also Figure 3-29-7). While still at peak intensity, Angela moved about 15 nm (28 km) north of the Catanduenas Island radar site (WMO 98446) and 40 nm (75 km) north of Virac, Catanduenas Island (WMO 98447). The radar site recorded gusts to 140 kt (72 m/sec) and Virac had gusts to 111 kt (57 m/sec). Since the radar site appeared to be in the southern eyewall, and the translation speed of Angela was toward the west at 10 kt (19 km/hr), a reasonable estimation of Angela's intensity when it passed to the north of Catanduenas at 021200Z (taking full account of the speed of translation and using a gust factor of 1.2) is 140 kt sustained 1-minute wind with gusts to 170 kt (72G87 m/sec).

Since Angela was not a small tropical cyclone, its wind and pressure would be expected to conform relatively well to the Atkinson and Holliday wind-pressure relationship, which gives a sustained 1-minute wind of 115 kt (59 m/sec) using the 926 mb minimum sea-level pressure recorded at Daet (WMO 98440) at 021900Z. Since the center of Angela's eye passed over Daet, this value — 115 kt with gusts to 140 kt (59G72 m/sec) — must be considered to be a reasonable estimate of Angela's intensity. The peak gust recorded at Daet was 135 kt (69 m/sec).

In the Metro-Manila area, wind and pressure measurements indicate that Angela's sustained winds had weakened to 80-90 kt (41-46 m/sec). The center of Angela appears to have passed near or over the Ninoy Aquino International Airport in Manila (WMO 98429) where a minimum sea-level pressure of 975.6 mb was recorded at 030230Z; the center of Angela also appears to have passed near or over Cubi Point (WMO 98426) where a minimum sea-level pressure of 976.3 mb was recorded at 030330Z.

#### IV. IMPACT

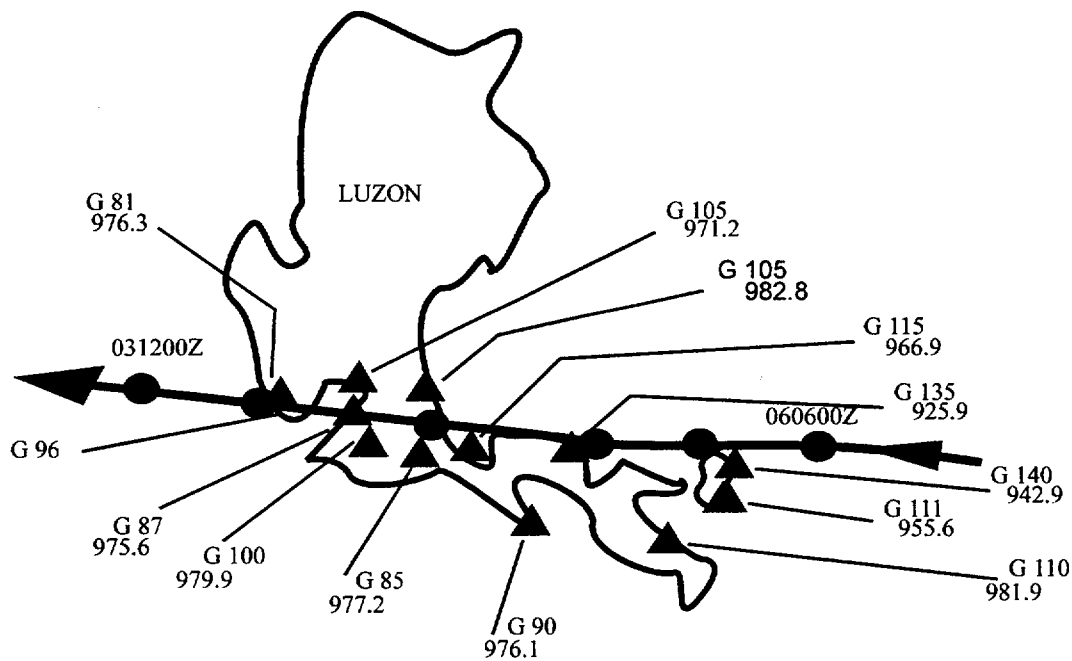
Angela caused considerable death, destruction, and agricultural losses in the Philippines. More than 600 people perished with an additional 100 reported missing. Over 96,000 homes were destroyed, and an estimated US\$70 million in damage was inflicted on roads and bridges. Hardest hit was the northern Bicol region of southern Luzon (located approximately 100-150 nm (185-280 km) southeast of Manila). Catanduenas Island and the Metro-Manila area were also hard hit. There were at least 121 deaths in Calauag, Bicol, primarily from storm surge and a river that flooded when a dam burst. More than 100 perished in the neighboring village of Paracale, primarily from mudslides. Damage to agriculture exceeded US\$18 million. Electrical power was lost by one-third of the country.

**Table 3-29-1**

## Intensity Comparison for Angela

Date/time	Average#	CI#	DD#	Synoptic Analysis
020000Z	7.0	7.5	6.9	7.5
020300Z	7.0	7.5	6.9	7.5
020600Z	7.0	7.5	6.8	7.4
020900Z	7.0	7.5	6.3	7.2
021200Z	7.0	7.5	6.0	7.0
021500Z	6.5	7.5	5.5	6.6
021800Z	6.0	7.0	5.8	6.3
022100Z	6.0	7.0		5.8
030000Z	6.0	7.0		5.4
030300Z	6.0	7.0		4.6

Date/time	Intensity (kt)	Intensity (kt)	Intensity (kt)	Synoptic Analysis
020000Z	140	155	138	155
020300Z	140	155	138	155
020600Z	140	155	136	150
020900Z	140	155	124	145
021200Z	140	155	115	140
021500Z	127	155	102	130
021800Z	115	155	110	120
022100Z	115	140		110
030000Z	115	140		100
030300Z	115	140		80



**Figure 3-29-7** Peak wind gusts and minimum sea-level pressures recorded at selected observation sites (solid triangles) as Angela crossed the Philippines. Angela's 6-hourly best-track positions are indicated by the black dots connected by the solid line.